THE W7FN EME ANTENNA

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EVOLUTION OF DESIGN

This EME array represents an evolution of thinking which was influenced by years of constructing antennas in the 50-432 MHz range and included an array for 50 MHz EME. Principal considerations affecting the design were:

a. Weather. (It's wet in the Northwest).

b. Neighbors. (Locate antenna close to the ground in the backyard to minimize the visual impact).

c. Small backyard with lots of trees. (Limit antenna to EU and W universal windows).

d. My own design. (KLM yagis and Cushcraft collinears obviously work, but I wanted to try some less accepted ideas.

e. Enough antenna gain to consistently get echoes. (Sun noise tests seem to indicate 21 to 22 dBd).

f. Lightweight. (May eventually want to get it up in the air).

g. No motorized EL-AZ position control. (I'm lazy, the antenna may not work - wait and see).

In the light of the above, my choice narrowed down to a number of small to medium length yagis and, because of the weather, coaxial phasing lines. Yagis up to about 6-7 elements offer reasonably predictable gain and a good gain vs. boom-length ratio. However, long boom yagis rapidly become unpredictable. Tilton's VHF Handbook spoke highly of both a 5-element and a 7-element design. Comparing the two designs revealed that their spacing and element lengths were quite similar. Thus one test antenna could be constructed to evaluate both. Since I've always had good luck with a simple gamma match design, I chose to use this coax compatible feed.

A test antenna was constructed with element lengths optimized for operation at 144 MHz. The antenna, by removing the front part of the boom and the last two directors, could be tested as either a 5-EL or a 7-EL yagi merely by rematching the feed point. This antenna was taken to the West

Coast VHF Conference held at San Diego in 1975. Gains measured on the antenna range were 9.5 dBd for the 5-EL and 11.0 dBd for the 7-EL version. The gain included a one-wavelength piece of RG-59/U that is used because its dielectric diameter is just right to slip inside 1/4 inch diameter tubing to make the gamma capacitor. Its' use also shakes up the troops who miss the fact that the antenna impedance (50 ohms in this case) is duplicated every half-wave, regardless of the coax impedance.

Boom lengths for the antennas were 66 inches for the 5-EL and 120 inches for the 7-EL. I decided to go with the 7-EL yagi as the extra 1.5 dB was well worth the added length. A quad configuration of these antennas was built in mid-1975 and has worked well for M.S. and tropo ever since. Wooden booms were used for this array as I've had a hangup for years about poor performance of metal boom antennas above 50 MHz. One thing that I soon found out with the quad of 7-EL yagis is that wooden booms warp into a corkscrew in our Northwest weather (the ants. still work, too).

A final choice of boom material for the EME array was made only after many months of pondering available options. I wanted to use non-warping, non-metalic material that was stiff and lightweight. Fiberglass seemed about the only solution. However, I wasn't about to try making the booms from raw materials. I finally chose the tapered, hollow fiberglass arms which are used by Cubex in manufacturing cubical quad antennas. They're expensive ($14/each) but worth it in this climate.

ANTENNA DETAILS

As purchased, the fiberglass arms are 13 feet long, hollow, and taper from 1¼ inch diameter at the butt end to 5/16 inch at the tip. The ten foot booms were cut by removing three feet from the large end. This resulted in a boom diameter of 1 inch at the large end - where the reflector was placed.

Figure 1 gives dimensions and shows details of the antenna and gamma feed. All parasitic elements are made from .125" diameter solid, tempered aluminum rod. The driven element and gamma rod are .250" diameter aluminum tubing. A wall thickness of .050" results in a very nice fit for the RG-59/U dielectric which is nominally .146" diameter. All elements pass through holes drilled in the boom and are held in place with a drop of epoxy on each side.

The length of the gamma rod, 8 inches, was arrived at by trial and error. The actual value of the gamma compensating capacitor is not at all critical. The shorting bar was made from ¼ x ½ inch aluminum bar, cut to 1-1/8 inch in length. Two .257" diameter ("F" Drill) holes, spaced 5/8 inch on centers accept the driven element and gamma rod. 6-32 Allen-head set-screws were threaded into each end of the bar. The 50 ohm impedance

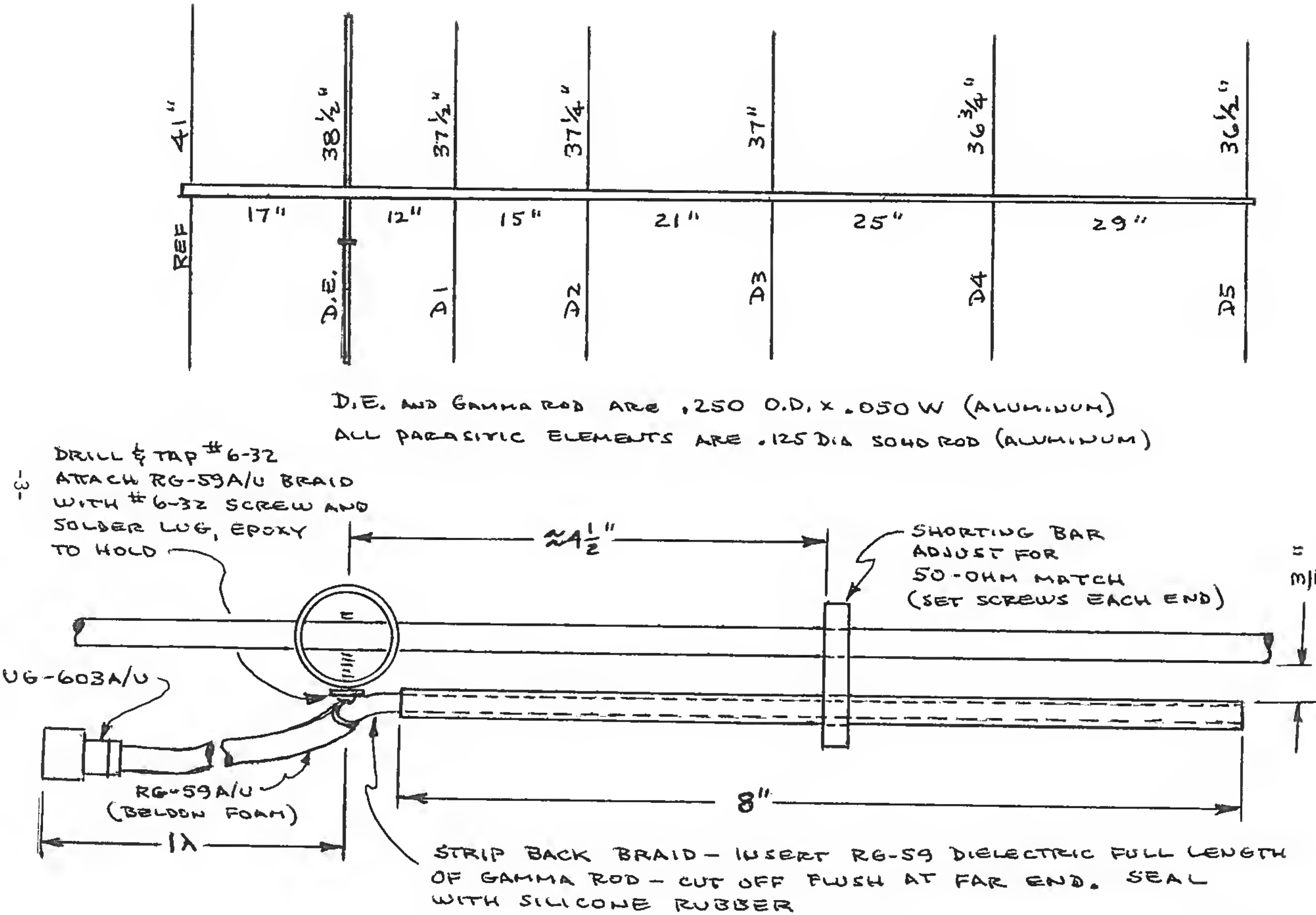


FIGURE 1 – ANT. DETAILS

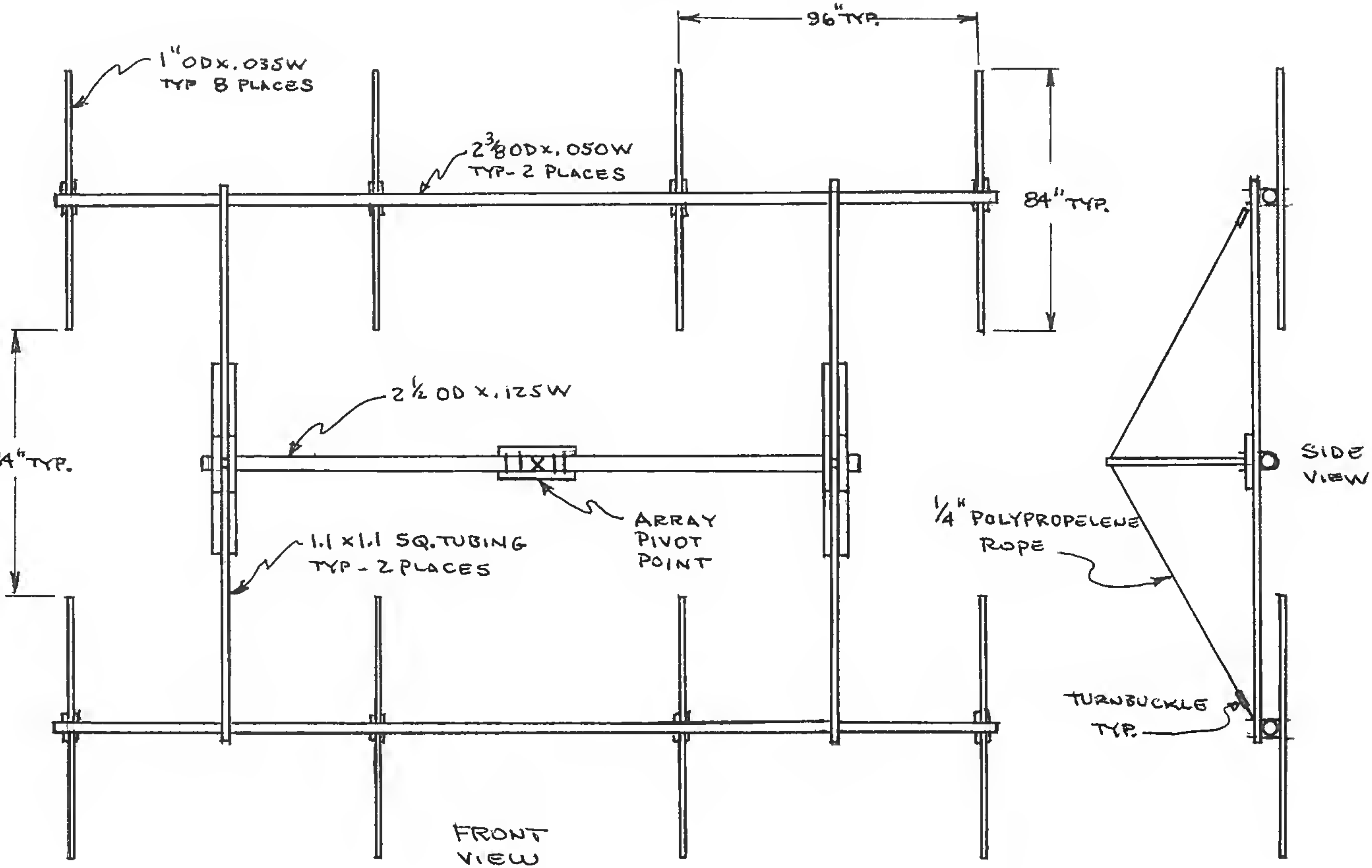
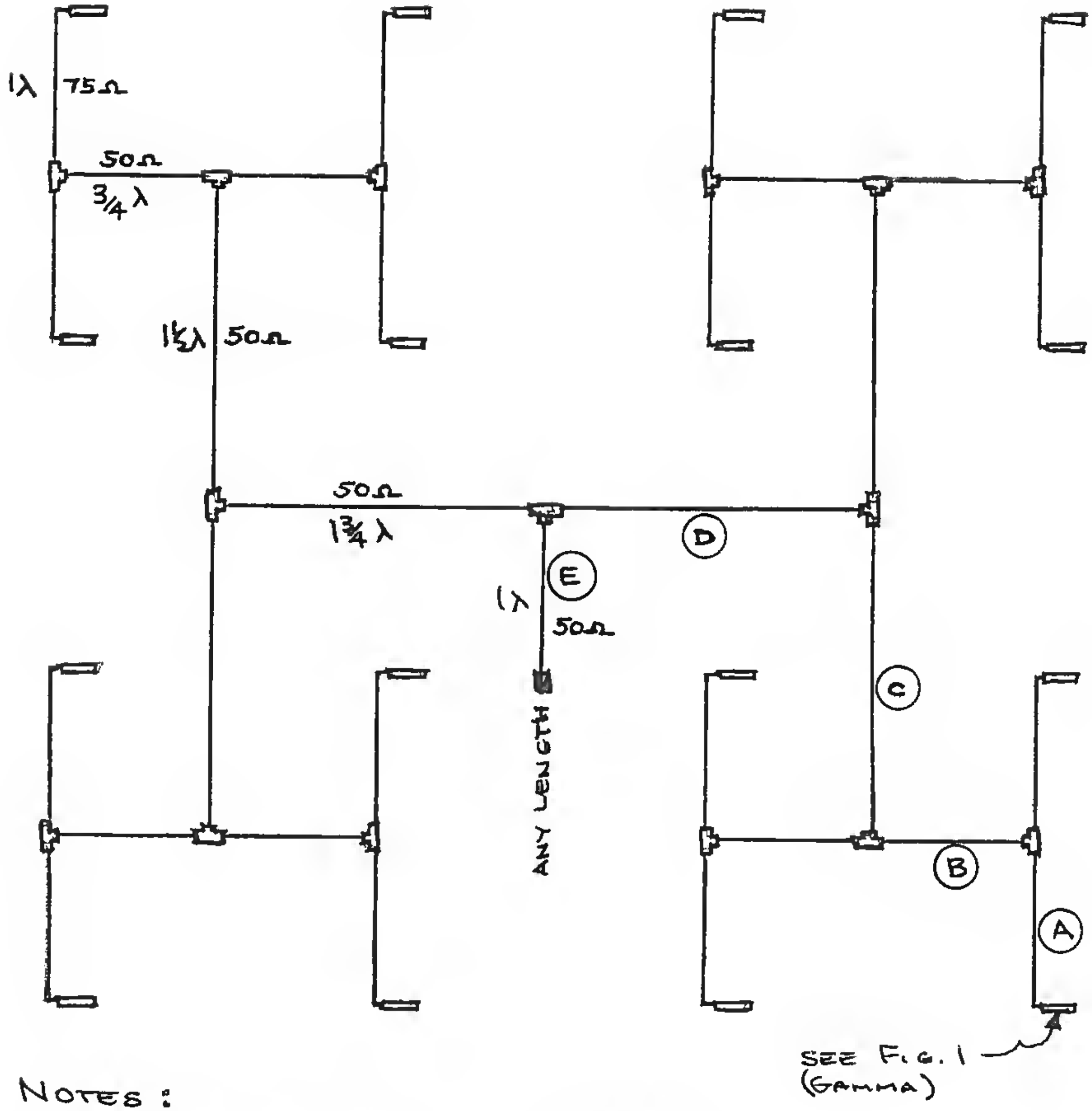


FIGURE 2 - SUPPORTING FRAMEWORK



NOTES:

1. PHASING HARNESS IS SYMETRICAL
2. ALL CONNECTIONS ARE "N" TYPE PLUGS & TEES
3. COAX (A) BELDON 8221 (FOAM) ≈ 63.5" × 16 PIECES
4. COAX (B) BELDON 8214 (FOAM) ≈ 47" × 8 PIECES
5. COAX (C) RG-8/U (POLY) ≈ 83" × 4 PIECES
6. COAX (D) RG-8/U (POLY) ≈ 95" × 2 PIECES
7. COAX (E) RG-8/U (POLY) ≈ 54" × 1 TO RELAY
8. WEATHER-PROOF ALL CONNECTIONS WITH PLASTIC TAPE AND SILICONE RUBBER.

FIGURE 3 - PHASING HARNESS

match was achieved with the shorting bar about 4½ inches from the center of the dipole. Each antenna, including gamma match, 1 λ of RG-59U coax, and the "N" connector weighs less than one pound.

SUPPORTING FRAMEWORK

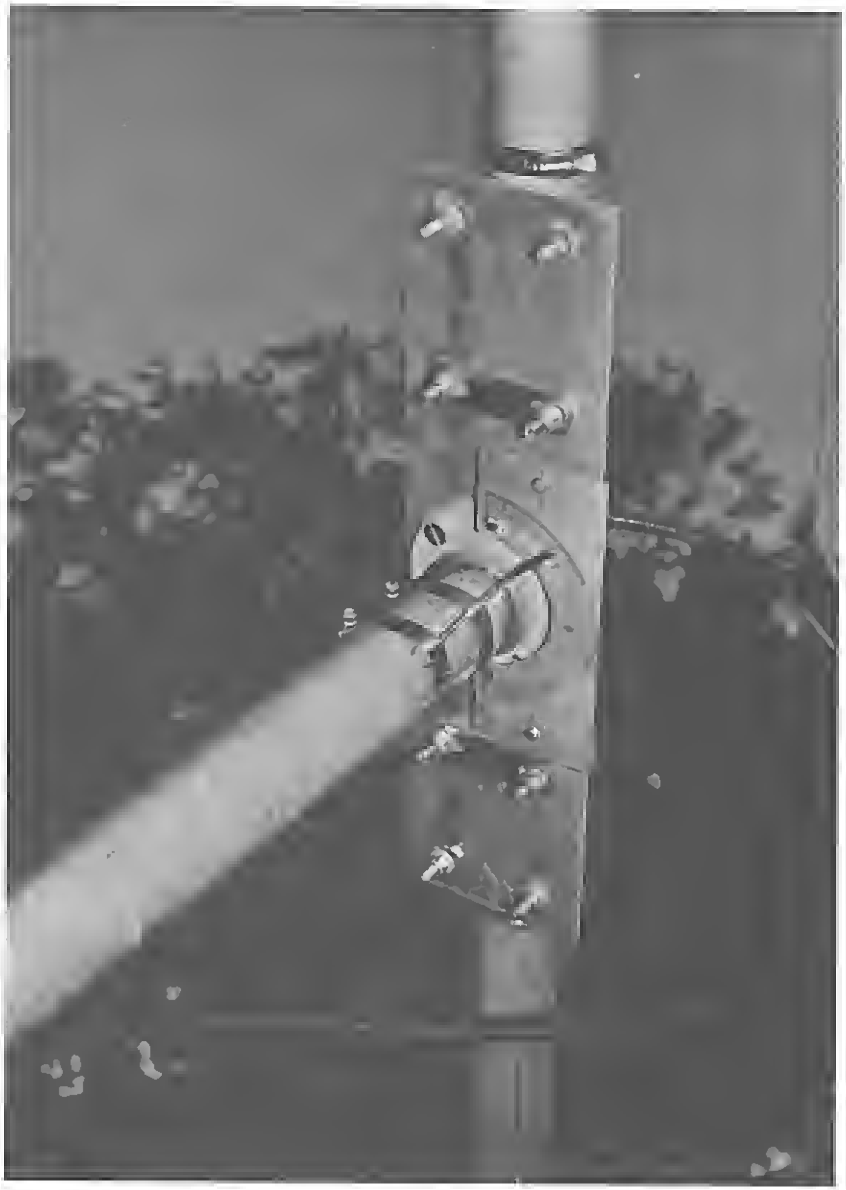
The supporting framework construction is shown by Figure 2. The main horizontal support is heavy-wall tubing but all other pieces were thin-wall and as light as possible. The two main vertical supports are square aluminum tubing for no reason except it was left over material from another project. These pieces required guying with ¼ inch polypropelene rope. No other guying was necessary. "U" clamps and aluminum plates were used throughout to tie things together. Either jam nuts or plastic-insert locknuts were used so that things would remain tight even though the nuts were tightened only enough to hold but not collapse the thin-wall tubing. The antenna booms were attached to each vertical support by a "T" shaped bracket formed from two pieces of "L" angle aluminum 3/4" x 3/4" x 1/8" by 6 inches long which were heli-arc welded together. Hose clamps, two for each boom and one for each vertical support, worked out very well. The total framework, without antennas and phasing lines weighed less than 50 pounds.

PHASING HARNESS

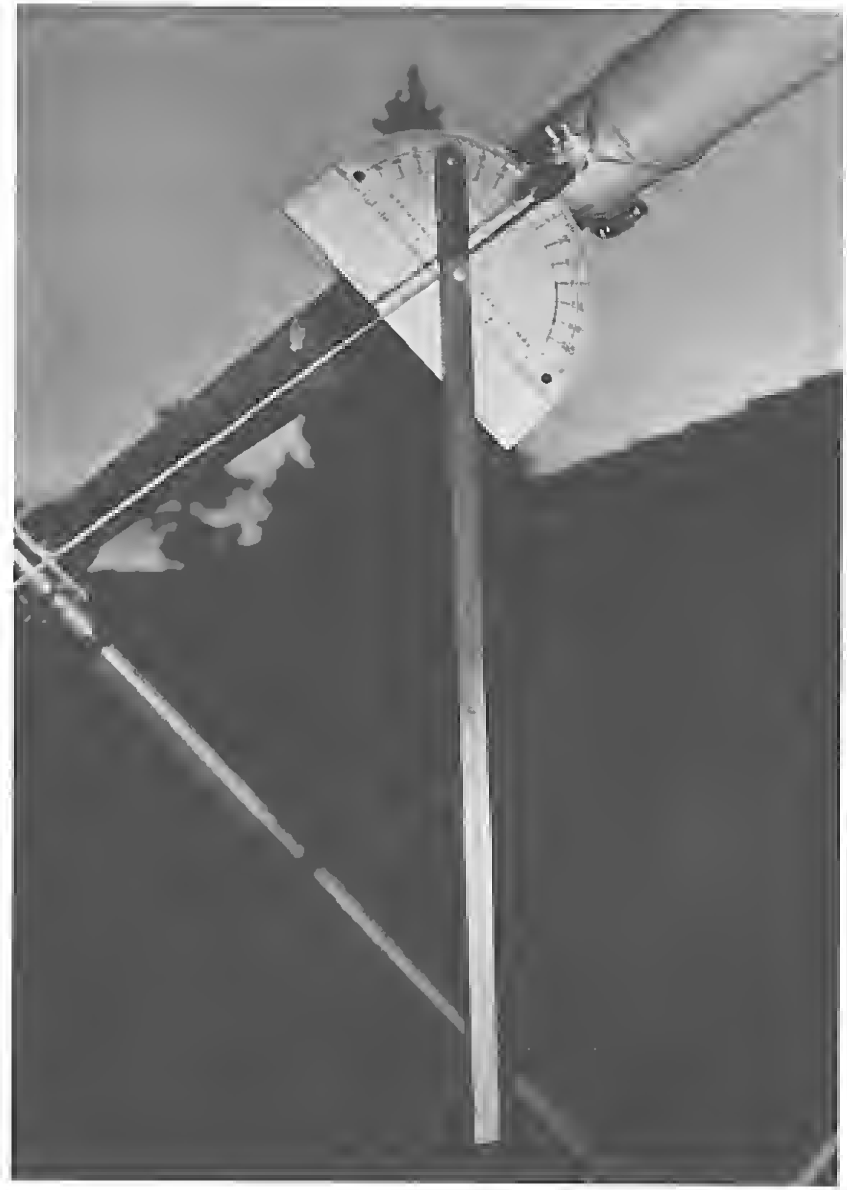
Figure 3 gives details of the phasing lines. Except for the 1 λ pieces of RG-59/U marked coax A, the phasing lines were made from RG-8/U coax. They are either foam or polyethelene dialectric depending on which would best match the antenna-spacing and odd-multiple $\lambda/4$ impedance transforming requirements. The electrical lengths of the pieces of coax were determined with a grid-dip-oscillator and took into consideration the coax connectors. Excellent impedance matching was achieved. Each antenna was individually matched for 50 ohms. Two of the antennas tied together was a 25 ohm impedance at one end of coax B and 100 ohms at the other. Two such impedances in parallel result in 50 ohm impedances at coax C. This same process repeats itself across coax D and E, resulting in a single 50 ohm impedance which is fed to the station by half inch semi-rigid coax. The antenna spacings of 8 feet horizontally and 7 feet vertically allowed the phasing harness to be neatly taped to the supporting framework.

ANTENNA ROTATION

As can be seen in the photographs, the entire array is supported on a single 2 inch I.D. waterpipe. This pipe is 15 feet in length with 3 feet in the ground. This leaves a height of 12 feet above ground. Threads at the top of this mast were "chased" with a file so that the pipe flange could be fully threaded onto the waterpipe. Wheel bearing grease was liberally



AZIMUTH INDICATOR



ELEVATION INDICATOR

applied to the threads. While this azimuth rotation appears crude, it works very well and allows the antenna to be rotated with one finger. A cheap plastic protractor and a pointer allows setting azimuth within 1^{o} and works much better than it looks.

ELEVATION

A 1/4 inch aluminum plate is bolted to the pipe flange. Four "U" bolts hold the main horizontal member of the framework in position yet allow it to rotate. As the antenna array is very nearly balanced, about ten pounds of scrap iron is mounted inside top horizontal thin-wall tubing. A small boat winch is mounted on the vertical waterpipe about 3 feet above ground. Enough steel cable is wound on the boat winch drum to allow the antenna to rotate a full 180^{o}. A second plastic protractor is mounted on the lower horizontal support where the winch cable is tied. A metal rod pivots at the center of the protractor and provides elevation readout within 1^{o}. The protractor readout system works amazingly well. I can preset the antenna to AZ-EL values according to a computer printout and, assuming the cloud cover allows me to see the moon, at the appropriate time bore-site along an antenna boom right to the moon. When the antenna is not in use, I let out the cable until the array is pointing straight up. This allows the antenna to be stored so that the reflectors are 7 - 8 feet above the lawn for lawnmowing, etc. Two poly ropes tie the antenna so that winds don't blow it around. The antenna has already gone through a 50 mph windstorm without a quiver.